STATE OF THE PACIFIC OCEAN 2012

Figure 1. The Pacific waters of British Columbia, Canada.

Context:

Pacific Canadian waters lie in a transition zone between coastal upwelling (California Current) and downwelling (Alaskan Coastal Current) regions, and experience strong seasonality and considerable freshwater influence. Variability is closely coupled with events and conditions throughout the tropical and North Pacific Ocean, experiencing frequent El Niño and La Niña events particularly over the past decade. The region supports important resident and migratory populations of invertebrates, groundfish and pelagic fishes, marine mammals and seabirds.

Monitoring the physical and biological oceanographic conditions and fishery resources of this region is done semi-regularly by several government departments, to understand the natural variability of these ecosystems and how they respond to both natural and anthropogenic stresses. Support for these programs is provided by Fisheries and Oceans Canada (DFO), and Environment Canada. Contributors to this report are members of the Fisheries Oceanography Working Group of the DFO Centre for Science Advice Pacific Region (CSAP), with additional contributions from other Canadian and American fisheries and climate scientists.

This Science Advisory Report is from the February 20-21, 2013 State of the Ocean: 2013 Workshop. Additional publications from this workshop will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- The global temperature in 2012 was warmer than the 20th century average almost everywhere, but not in the northeast Pacific Ocean where cool waters have been present in almost every year since 2007; this is part of a Pacific-wide weather pattern associated with La Niña conditions of these years.
- An intense bloom of phytoplankton was observed by MODIS satellite in the Gulf of Alaska more than 200 nautical miles west of Haida Gwaii in August 2012.
- Off the west coast of Vancouver Island, the zooplankton community contained more cool-water zooplankton than average, which is associated with good local survival and growth of young salmon and other fish, as well as plankton-eating sea birds.
- Non-Fraser southern Sockeye Salmon stocks continued to exhibit re-building, while those from the central and north coast continued a decadal-scale, sub-average return trend through 2012.
- The number of Pink Salmon returning in even-numbered years, including 2012, tend to be stable, while populations returning in odd years, are generally increasing.
- In 2012, research cruise catch rates of juvenile Chum, Sockeye, Coho and Chinook Salmon were generally higher off the west coast of Vancouver Island and in the central coast than in 2011, while they were at or above the 1998-2012 long-term average for all species.
- A detailed study of Puget Sound waters revealed significant changes in oxygen concentration in waters below 20 metres depth over the past decade, with highest concentration in 2002 and 2012, and significantly lower concentration in 2005 to 2009. These changes correlate well with variations in the strength of upwelling winds off the west coast, suggesting that intrusions of deep coastal water into Puget Sound are a main cause. A longer time series is available for the Strait of Georgia, where oxygen concentration in deep waters over the past half century declined, attributed to similar declines in deep waters on the continental shelf that advect into the strait.
- Phytoplankton in the Strait of Georgia bloom in the late winter and early spring, reaching a peak when they have consumed all nutrients in the surface layer. The timing and duration of this peak of the spring bloom is believed to affect the survival of juvenile salmon and herring. The spring bloom of phytoplankton in the Strait of Georgia in 2012 was later than normal and similar in timing to the previous 6 years.
- Juvenile salmon from the Fraser River generally enter the Strait of Georgia from April to June, many remaining there until the fall. A multi-year study of tagged sockeye salmon smolts exiting Chilko Lake in the Fraser River watershed found consistent early survival patterns among years. Tagged fish moved rapidly through the Strait of Georgia and Queen Charlotte Strait. Large catches of two-year-old juvenile Sockeye Salmon in research trawl surveys in the Strait of Georgia in 2012 resulted from record high returns to the Fraser River in 2010.

BACKGROUND

This report is the fourteenth in an annual series on the state of physical, biological, and selected fishery resources of Canadian Pacific marine ecosystems. The region supports important resident and migratory populations of invertebrates, groundfish and pelagic fishes, marine mammals and seabirds. Monitoring the physical and biological oceanographic conditions and

fishery resources of the Pacific Region is done semi-regularly by scientific staff in several government departments, to understand the natural variability of these ecosystems and how they respond to both natural and anthropogenic stresses. Support for these programs is provided by Fisheries and Oceans Canada, Environment Canada, Parks Canada and the Department of National Defence. Additional information is provided by the US National Oceanographic and Atmospheric Administration (NOAA), University of Victoria, and the University of British Columbia.

More detailed information is available in Irvine, J.R. and Crawford, W.R. 2013. State of physical, biological, and selected fishery resources of Pacific Canadian marine ecosystems in 2012. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/032.

ASSESSMENT

This report summarises results from the fourteenth annual workshop on the state of physical, biological, and selected fishery resources of primarily Canadian Pacific marine ecosystems.

The average global temperature in 2012 was warmer than the 20th century average almost everywhere, but not in the northeast Pacific Ocean, where cool waters have been present in almost every year since 2007, part of a Pacific-wide weather pattern associated with La Niña conditions of these years.

Sea surface measurements from shore stations along the coast of British Columbia and in the Salish Sea, confirm that ocean conditions were cooler in 2012 than in 2011 and 2010. Preliminary results of measurements by a Continuous Plankton Recorder through the eastern Gulf of Alaska were partially processed at press time, revealing somewhat lower biomass of large diatoms (a type of phytoplankton) than usual, and much larger biomass of copepods. Both these results are compatible with cool ocean surface waters. Satellite imagery detected a very strong bloom of coccolithophores west of northern Vancouver Island in June 2012, the strongest bloom of the 11-year record.

An intense bloom of phytoplankton was observed by MODIS satellite in the Gulf of Alaska more than 200 nautical miles west of Haida Gwaii in August 2012. Given its location, size and intensity, there is speculation that a linkage could be drawn to fertilization of the ocean with iron-rich material, as part of a project undertaken by the Haida Salmon Restoration Corporation. Further analysis is required to confirm or reject this hypothesis.

Albacore tuna catches in Canadian waters increased in 2012 relative to the previous year, but were probably related to increased effort. Off the west coast of Vancouver Island (WCVI), the zooplankton community contained more cool-water zooplankton than average, which is associated with good local survival and growth of young salmon and other fish, as well as plankton-eating seabirds such as Cassin's Auklet. Walleye Pollock and smooth pink shrimp densities increased in 2012 off the WCVI, while eulachon, herring, and sardine numbers remained relatively low throughout BC. Nearshore fish populations in eelgrass and kelp beds of Pacific Rim National Park Reserve tend to vary more among areas than years.

Non-Fraser southern Sockeye Salmon stocks continued to exhibit re-building while those from the central and north coast continued a decadal-scale, sub-average return trend through 2012. The number of pink salmon returning in even-numbered years, including 2012, tend to be stable while populations returning in odd years, including the Fraser, are generally increasing. In 2012, juvenile Chum, Sockeye, Coho and Chinook Salmon catch rates in research surveys were generally higher off the WCVI and in the central coast than in 2011, and at or above the 1998-2012 long-term average for all species.

Waters of the Salish Sea, comprising Juan de Fuca Strait, Puget Sound and the Strait of Georgia and adjacent waters, host a separate ecosystem from offshore waters. A detailed study of Puget Sound waters since 1998 revealed systematic changes, many of which were due to intrusions of oceanic water. For instance, the average oxygen content of Puget Sound waters below 20 metres depth varies with the upwelling index off the west coast of Washington State. Oxygen concentration declined in the past 5 or so years, although it rebounded in 2012. A longer time series is available for the Strait of Georgia, where oxygen concentration in deep waters over the past half century declined, attributed to similar declines in deep waters on the continental shelf that advect into the strait. This decline in oxygen is of concern because oceanic sub-surface water in our region that is deficient in oxygen is often more acidic, and ocean acidity will increase everywhere as more carbon dioxide is added to the atmosphere.

Phytoplankton in the Strait of Georgia bloom in the late winter and early spring, reaching a peak when they have consumed all nutrients in the surface layer. The timing and duration of this peak of the spring bloom is believed to affect the survival of juvenile salmon and herring. The peak of the spring bloom of phytoplankton in the Strait of Georgia in 2012 was later than normal and similar in timing to the previous 6 years, and a late spring bloom is predicted for 2013. Recent zooplankton biomass appears to be similar to the high levels found during 1999-2002.

Juvenile salmon from the Fraser River generally enter the Strait of Georgia from April to June, many remaining there until the fall. A multi-year study of tagged Sockeye Salmon smolts exiting Chilko Lake in the Fraser River watershed found remarkably consistent early survival patterns among years, with significant en-route freshwater mortality occurring in upstream, clear tributaries. Tagged fish moved rapidly through the Strait of Georgia and Queen Charlotte Strait. Because many of the juvenile Sockeye Salmon caught in research trawl surveys in the Strait of Georgia in 2012 were progeny of the record return of Sockeye Salmon to the Fraser River in 2010, it was not surprising that the catch per unit effort of juvenile Sockeye Salmon in the early summer survey of 2012 was the highest since regular sampling began in 1998.

Sources of Uncertainty

Sources of uncertainty include measurement and random sampling errors as well as unknown or poorly understood functional relationships among species and their oceanographic ecosystem.

CONCLUSIONS

Monitoring the physical and biological oceanographic conditions and marine fishery resources of the Pacific Region is essential to understanding the natural variability of these ecosystems and how they respond to natural and anthropogenic stressors. 2013 is the 14th consecutive year that "State of the Ocean" reports have been published in a consolidated format; a time series of tremendous value.

Developing standardized, quantitative indices to document changes in the health of the ocean and status of its marine species, as part of an ongoing ecosystem approach to management, is an important direction for future State of the Ocean reporting. Consistently monitored indices will enable the development of tools and products to advise resource managers on the impact and management options for human activities in the marine environment.

SOURCES OF INFORMATION

This Science Advisory Report is from the February 20-21, 2013 State of the Ocean: 2013 Workshop. Additional publications from this workshop will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

Further details on the 2013 State of Ocean workshop are provided in:

Irvine, J.R. and Crawford, W.R. 2013. State of the physical, biological, and selected fishery resources of Pacific Canadian marine ecosystems in 2012. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/032.viii+136 p.

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